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Impact of Mining on Railway Line at Sudamdih Shaft Mine

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झरिया कोयलांचल भारत में उत्तम कोककारी कोयले का एक महत्वपूर्ण स्रोत है। इस कोयलांचल के दक्षिण भाग में सुदामडीह – कूपक खान (Shaft-Mine) है, जहाँ से लगभग 8 लाख टन कोककारी कोयला बालूभरण (Hydraulic Sand Stowing) विधि से निकाला गया है। यह कोयला तीन संस्तरों (VIIIA, IX/X और XI/XII) से निकाला गया है। आद्रा–गोमो मुख्य रेलवे लाइन जो कि दक्षिण–पूर्व रेलवे में पड़ती है, इस कूपक खान के ऊपर से गुजरती है। इसके अलावा इस कोयला खान के ऊपर दामोदर नदी, आवास और अजात पुराना कोयला कार्य–क्षेत्र है।

इस कोयला खान में संस्तरों का झुकाव 28° से 55° तक है। इनकी गहराई 35 मी. से लेकर 400 मी. तक है। यहाँ कोयले को आरोही–आनत–फॉक तथा द्रवीय बालू–भरण विधि (Ascending inclined slicing with hydraulic sand stowing) से बाहर निकाला गया है। सुदामडीह–कूपक खान में केन्द्रीय खनन अनुसंधान संस्थान 1971 से कोयला निकालने से मुख्य रेलवे लाईन पर धँसान (Subsidence) के प्रभाव का अध्ययन कर रहा है। अध्ययन से प्राप्त निष्कर्ष के अनुसार, यहाँ अधिकतम धँसान 672 मि. मी., ढाल (Slope) 10.5 मि. मी./मी. तथा तनाव (Strain) 3.1 मि. मी./मी. पाया गया है। इसके बावजूद भी रेलवे पटरी पर किसी भी तरह का कोई प्रभाव नहीं पड़ा है।

Sudamdih project of Bharat Coking Coal Limited (erstwhile N.C.D.C.) lies on the southern flank of Jharia Coalfield basin. At Sudamdih Shaft Mine three thick seams, namely, VIIIA, IX/X and XI/XII are being extracted by ascending slicing method with hydraulic sand stowing underneath and in the vicinity of important surface and sub-surface properties. The sequence of the coal seams are given in Table 1.

Table 1

Sequence of Coal Seams

Sl. No.	Coal seams	Seam thickness (m)	Parting thickness (m)
1.	Sub-soil and cover	—	39.6 – 90
2.	XVIII Top seam	3.5 – 4.7	—
3.	Parting	—	18.6 – 22.2
4.	XVIII Bottom seam	2.3 – 3.2	—
5.	Parting	—	57.6 – 69.0
6.	XVII seam	3.0 – 7.7	—
7.	Parting	—	18.6 – 30.6
8.	Local-1 seam	0.7 – 4.3	—
9.	Parting	—	10.5 – 30.6
10.	Local-2 seam	1.7 – 4.3	—
11.	Parting	—	91.5 – 96.6
12.	XVI Top seam	1.6 – 3.1	—
13.	Parting	—	20.4 – 49.1
14.	XVI Bottom seam	0.7 – 3.1	—
15.	Parting	—	10.5 – 54.0
16.	XVA seam	1.7 – 5.6	—
17.	Parting	—	7.2 – 31.5
18.	XV seam	7.5 – 16.2	—
19.	Parting	—	7.2 – 31.5
20.	XIV A seam	1.3 – 2.7	—
21.	Parting	—	11.5 – 54.0
22.	XIV seam	2.1 – 14.6	—
23.	Parting	—	87.0 – 120.0
24.	XI/XII seam	4.8 – 12.9	—
25.	Parting	—	77.4 – 111.0
26.	IX/X seam	12.0 – 27.0	—
27.	Parting	—	11.5 – 30.6
28.	VIII A seam	3.5	—
29.	Parting	—	34.4
30.	Local seam	3.2	—
31.	Parting	—	37.5
32.	VIII seam	4.1	—
33.	Parting	—	21.0 – 30.0
34.	VII seam	2.0 – 2.2	—
35.	Parting	—	3.0 – 3.6
36.	V/VI seam	8.4	

Most of the coal seams out-crop in the area. Since the area lies on the outskirts of the basin, the seams have been affected by geological disturbances. The dip of the seams in the area varies from 27° to 55° which have been affected by numerous faults.

Initially coal mining in the area was done by open casting in the vicinity of out-crops. Later the mining was

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done by driving inclines from the surface. A few shafts were also sunk. Due to adverse gradient and geological conditions the seams were developed by bord and pillar system mainly along the strike. In some areas reduction of pillars was done before abandoning the mines. In some places collapse of old workings, having reduced pillars, caused sudden subsidence on the surface and a few pot-holes also occurred (Fig.1).

After nationalisation, extensive programme was drawn for coking coal seams for the area by KOPEX, a Polish Consulting Firm. In the project report it was proposed to extract the seams upto a depth of about 150m from Incline Mines. After leaving a vertical barrier of 50m the seams were planned to be extracted by two shafts sunk for the purpose (Fig.2).

In both stages and places the extraction of seams was planned by ascending longwall slicing and chamber methods in conjuction with hydraulic sand stowing due to the following reasons :

- Semi-steep to steep gradient of the coal seams.
- Thickness of seams generally being more than 3m.
- Large number of coal seams in close proximity.
- Presence of surface features and structures like Adra-Gomoh main railway line of S. E. Railway, auxilliary railway siding, Damodar river, D. B. road and buildings, etc.

After initial development, the extraction by longwall ascending slicing with hydraulic sand stowing was started in XI/XII seam (about 7.5m thickness) from the Incline mine in 1969. Since, there were important surface features and structures, it was felt necessary to investigate subsidence behaviour in the area. Accordingly Central Mining Research Institute, Dhanbad, started subsidence investigations in 1969 with the commencement of extraction.

In 1970-71, it was proposed to extract XI/XII seam at the Incline Mine from underneath and in the vicinity of Adra-Gomoh railway line of South Eastern Railway. On the basis of subsidence observations in the area and on the basis of experience and knowledge gained in India and abroad, it was recommended to extract 6m thickness of the seam in two ascending slices upto 60m depth of cover and 3m thickness of the seam upto a limit of 30m depth of cover with hydraulic sand stowing. The observations in XI/XII seam were continued simultaneously by CMRI, Dhanbad.

At Shaft Mine extraction was started in 20m thick XI/XII seam in 1975 and in VIIIA seam in 1981-82. The subsidence monitoring was also extended to study the effect of subsidence on the railway line. About 8 million tonne of coking coal has been extracted from these seams underneath and in the vicinity of the railway line and important surface properties without causing practically any problem.

The authors through this paper, would like to emphasis that practising mining engineers must think globally and act locally.

DETAILS OF WORKINGS

Studies of the subsidence behaviour of the workings in the three thick seams (VIIIA, IX/X and XI/XII) were undertaken by CMRI, Dhanbad since 1971 underneath and in the vicinity of important surface properties, such as :

(i) Adra-Gomoh main railway line of South Eastern Railway,

(ii) An auxilliary railway siding,

(iii) Damodar river,

(iv) Unknown and unapproachable (water logged) workings in XIV, XIVA, XV and XVI seams.

The positions of workings in the three seams are also shown in Fig.3. The details of workings are as follows :

1.	Coalfield	: Jharia			
2.	Colliery	: Sudamdih Shaft and Incline Mines			
3.	Seams	: VIIIA	IX/X	XI/XII	
4.	Panels/ Blocks	: 1, 2, 3, 4** 5, 6, 7E, 8E	2, 4, 4A 6**	4, 4A, 8, 8A 14 to 20* 2, 2A, 4, 6, 8 and 11*	
5.	Seam thickness	: 5.5 m	20m	7.5m	
6.	Extraction thickness	: 5.5 & 3m	3–12m	7.5m	
7.	Dip of seam	: 1 in 2	1 in 2	1 in 2	
8.	Depth	:			
	(a) Minimum	200m**	200m**	35m*	200m**
	(b) Maximum	400m	300m	135m	400m
9.	Dip of the seams	: 27° to 35°			
10.	Method of extraction	: Ascending longwall slicing			
11.	Goaf support	: Hydraulic sand stowing.			
12.	Geological disturbances	: Low angle faults mainly in shaft mine workings between 300m and 400m horizons.			
13.	Period of extraction	: 1981 continuing	1975 continuing 1971 continuing	1971-76*	
14.	Surface properties	: (i) Adra-Gomoh railway line of S. E. Railway (ii) An auxilliary railway siding (iii) Damodar river (iv) D. B. road (v) Building, etc.			
15.	Previous working around	: Unknown and unapproachable (water logged) workings in XIV, XIVA, XV and XVI seams.			
16.	Percentage of extraction in panels/blocks	: 100	100	100	

* Incline mine workings
** Shaft mine workings.

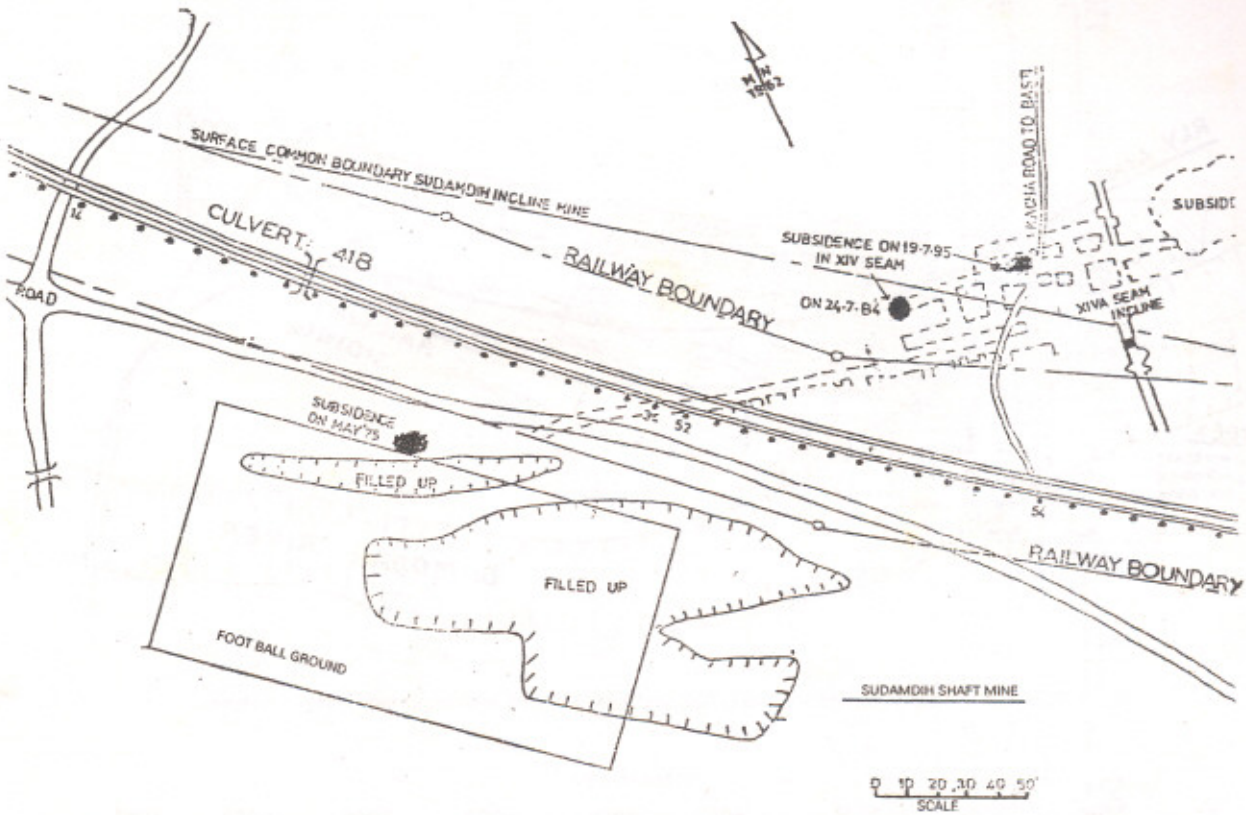

Fig. 1 : Part Surface Plan showing Monitoring Stations along Railway Line, Roads, Foot Ball Ground etc.

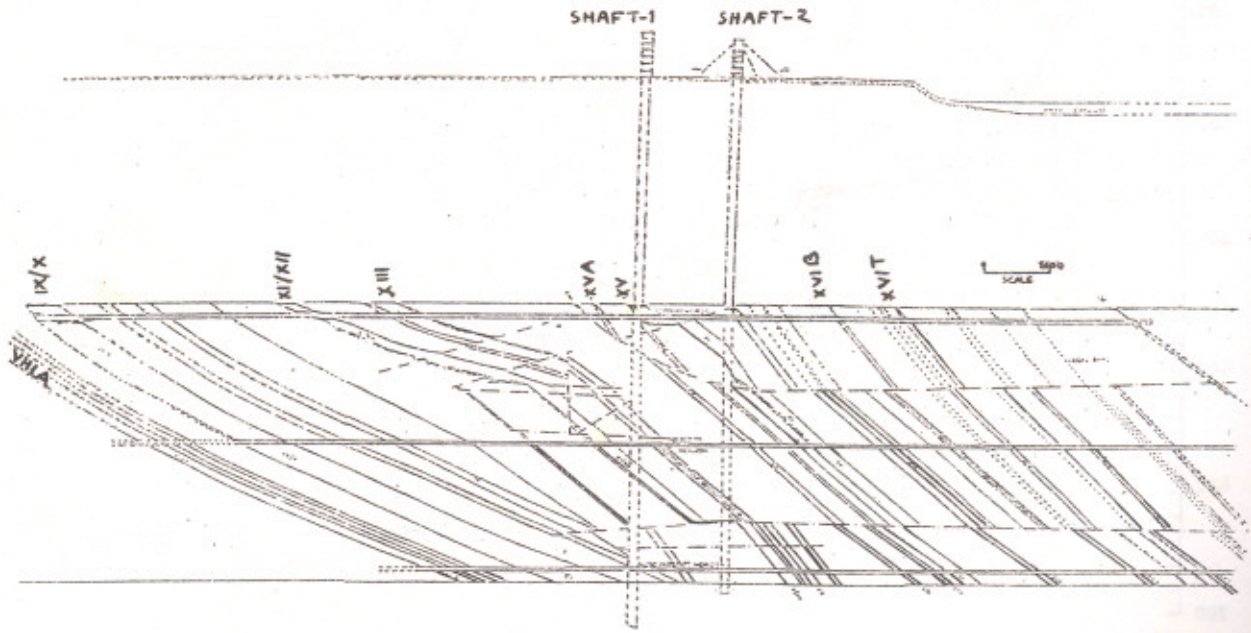

Fig. 2 : Cross Section along Cross-cut N-S

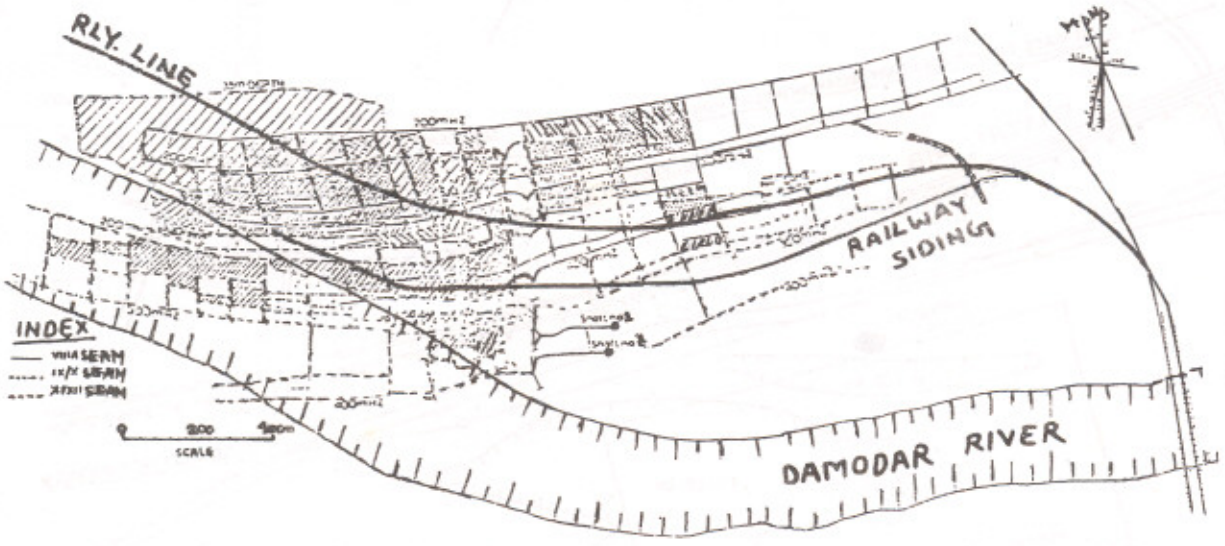

Fig.-3 Part plan showing workings in VIIIA, IX/X and XI/XIII seams with important surface features

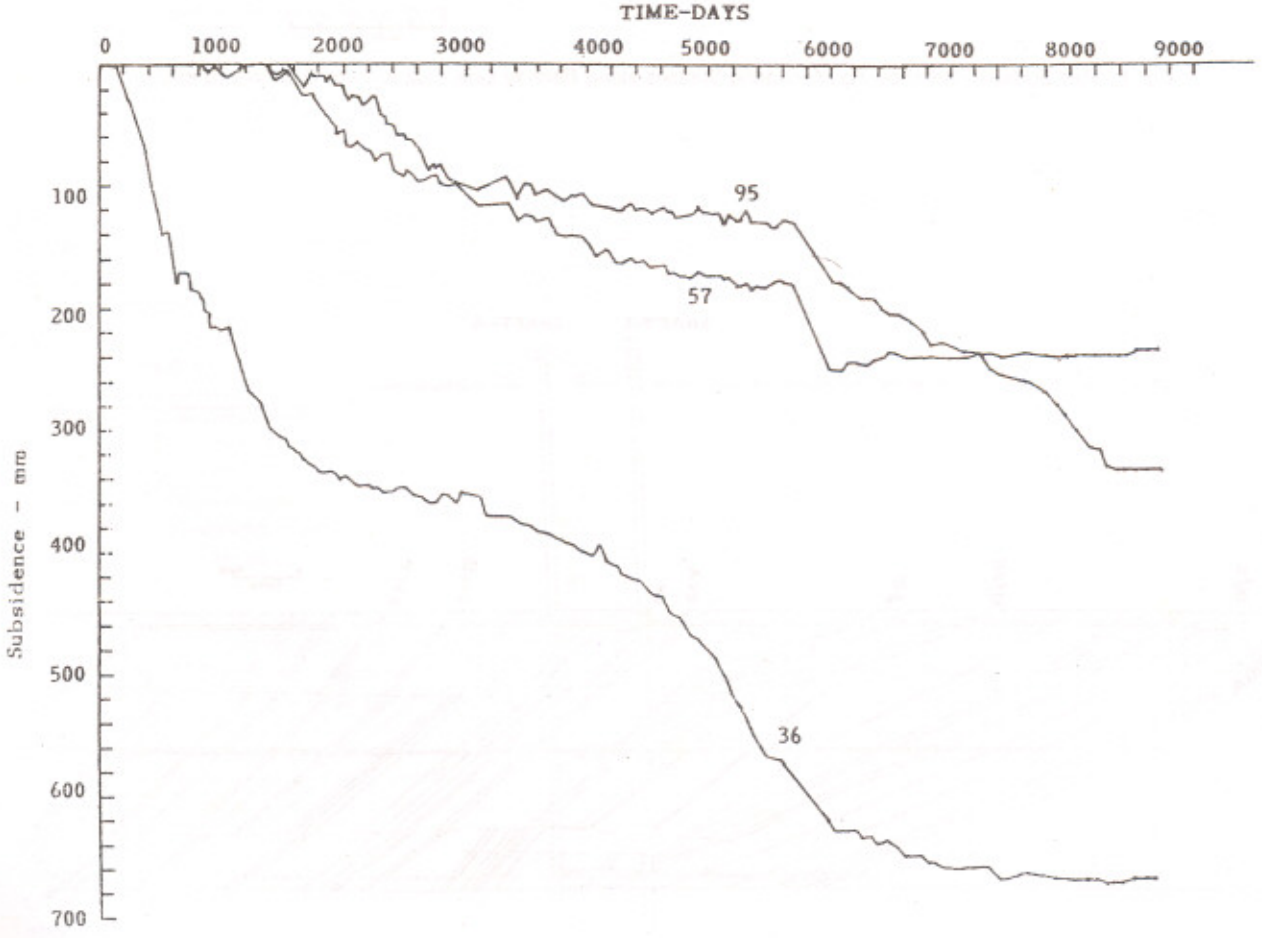

Fig. 4 : Subsidence time relationship along the Railway Line

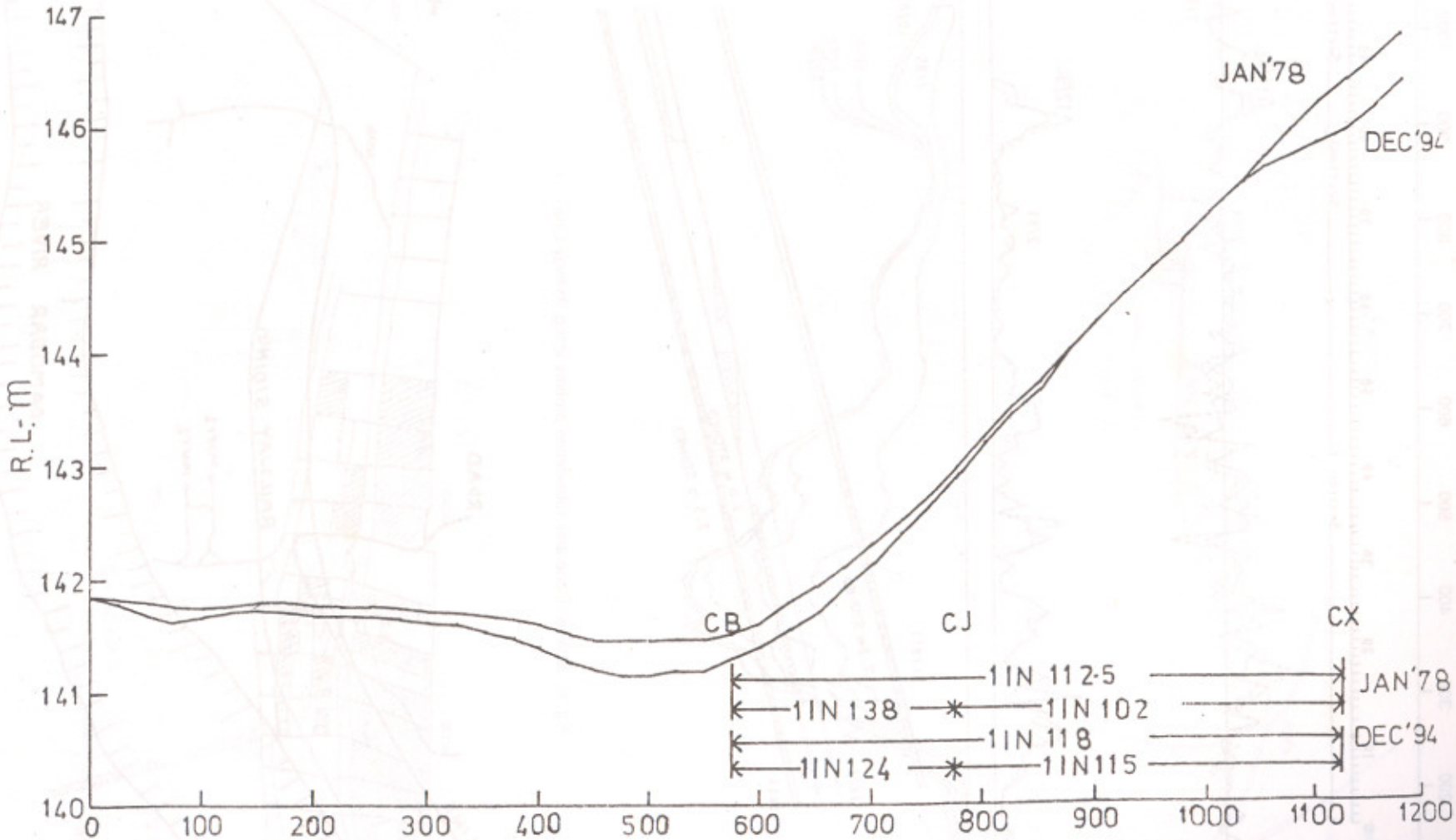

Fig. 5 : Profile of the Railways Line

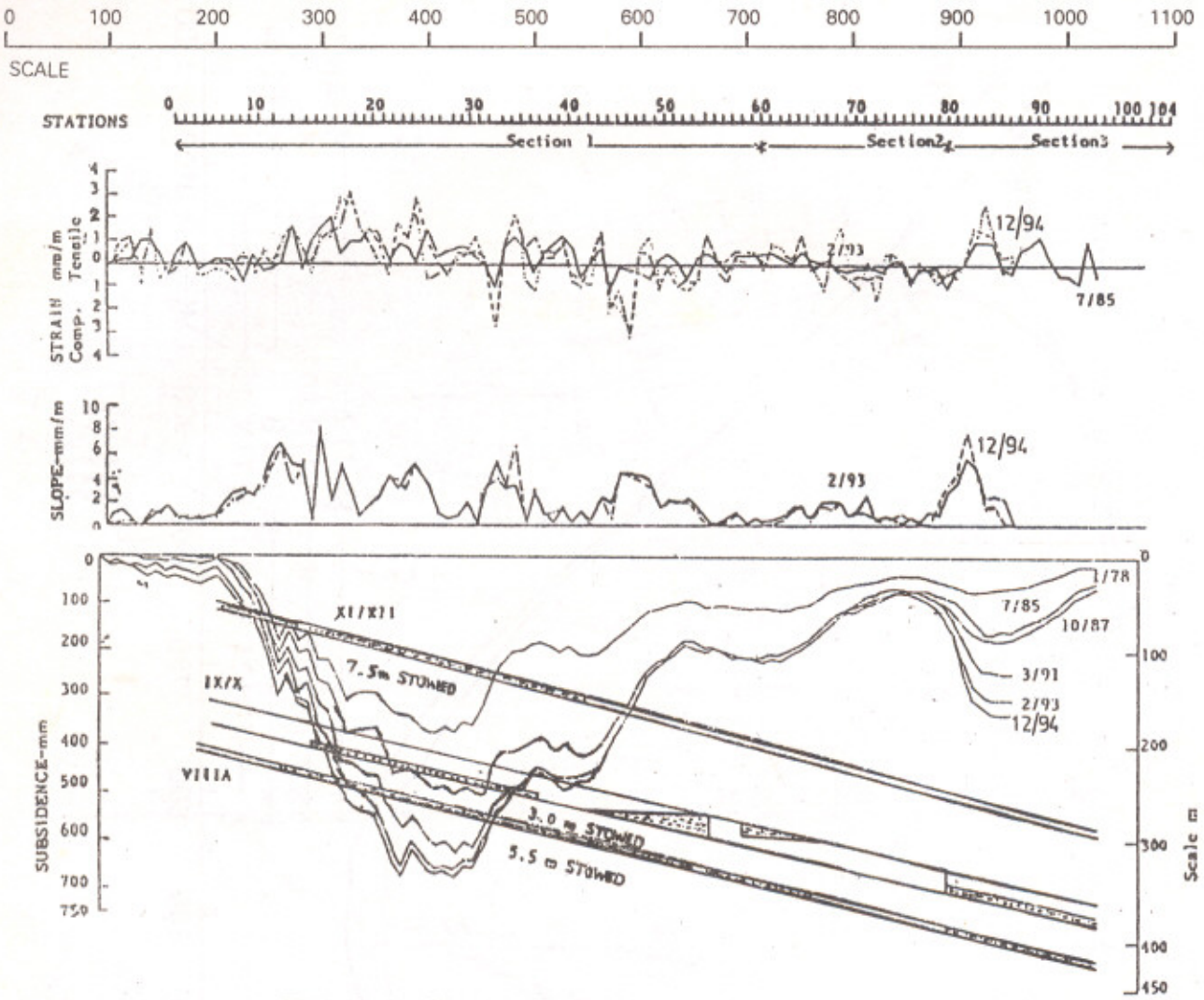

Fig. 6 : Strains, Slope and subsidence profiles along Railway Line

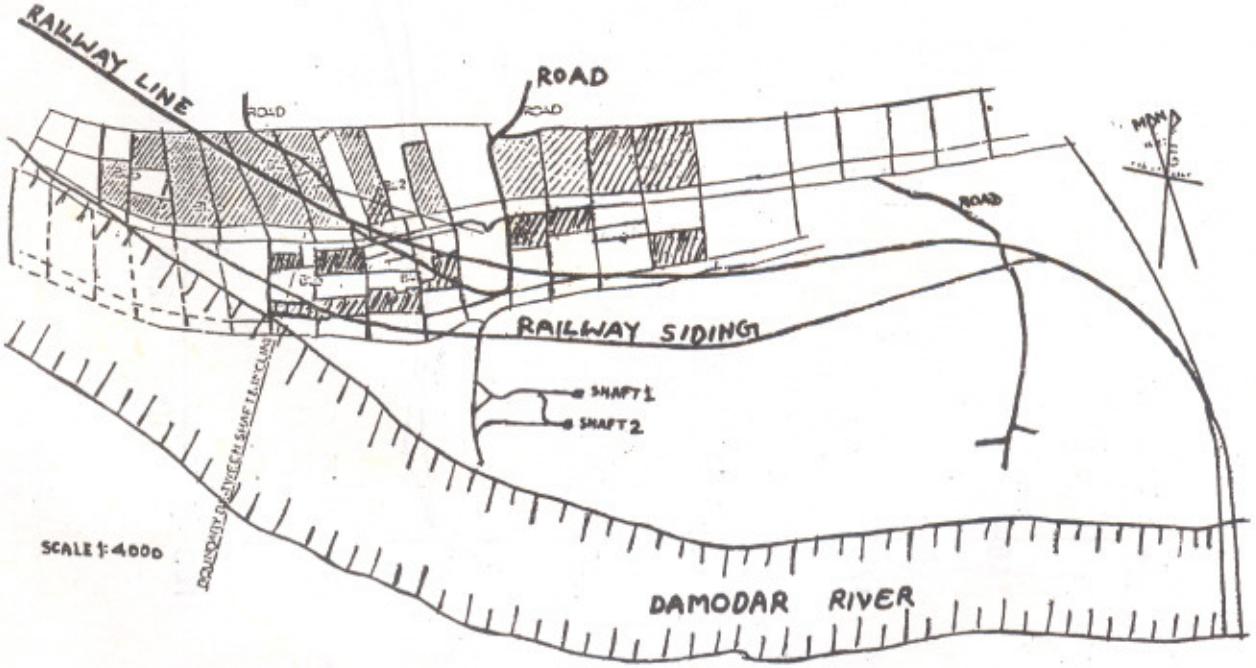

Fig. 7 : Working in VIIIA Seam with important surface features

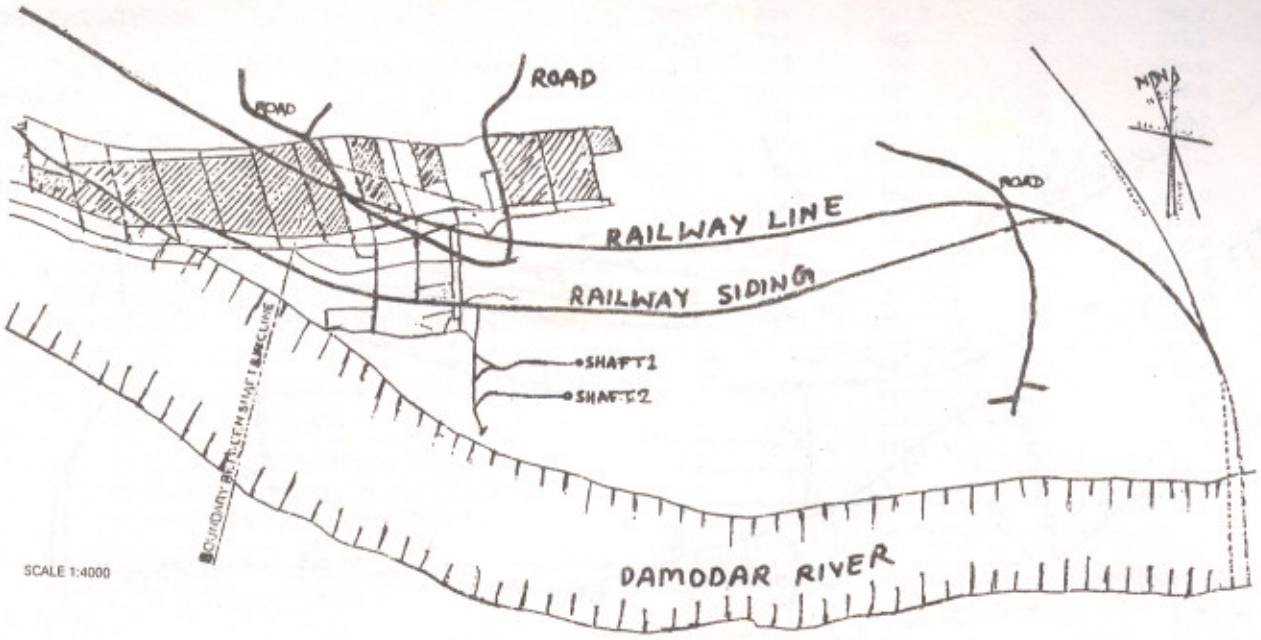

Fig. 8 : Part Plan showing working in IX/X Seam with important surface features

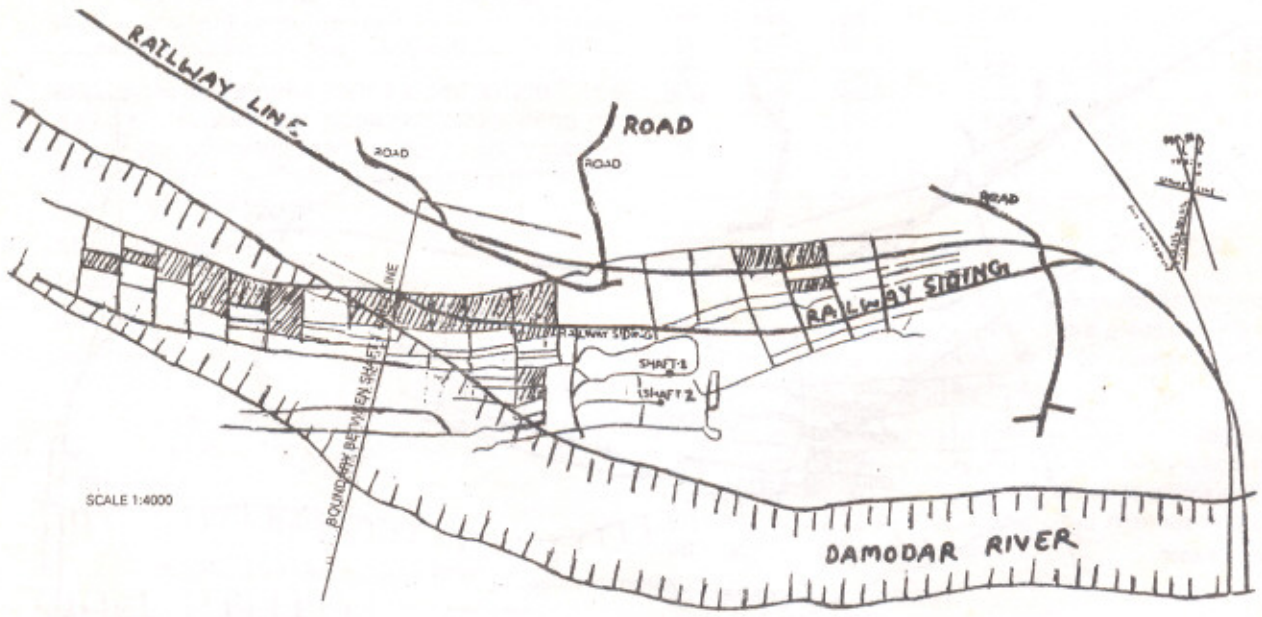

Fig. 9 : Part Plan showing working in XI/XII Seam and important surface features

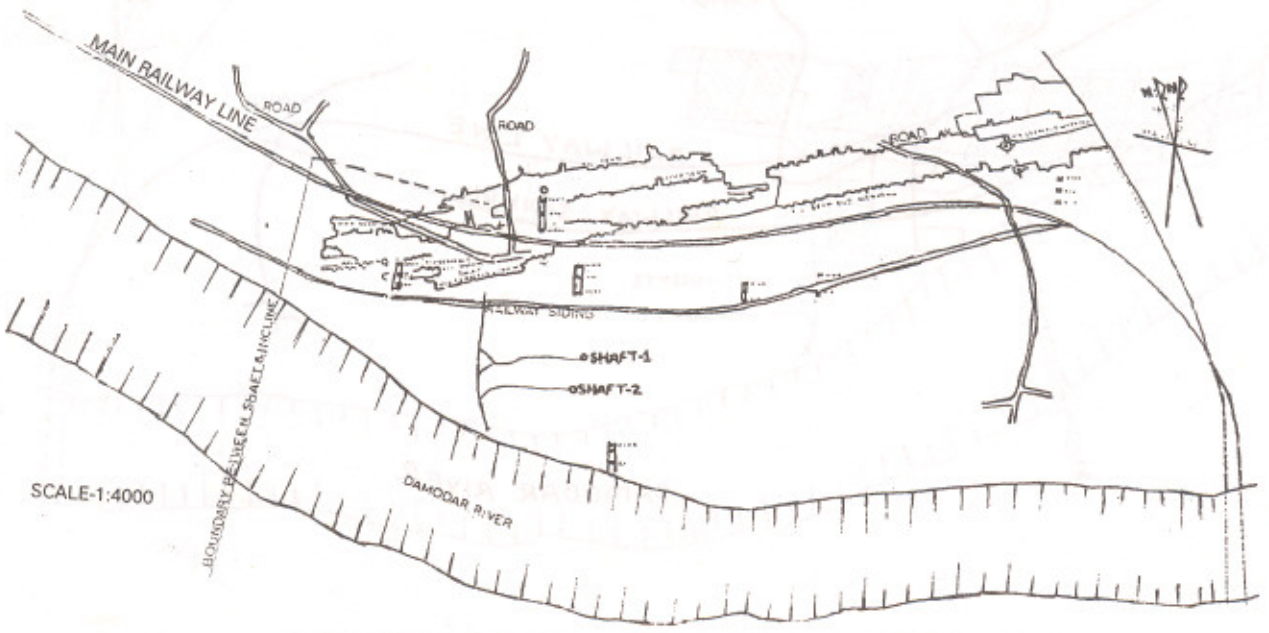

Fig. 10 : Sudamdih Shaft Mine XIV Seam

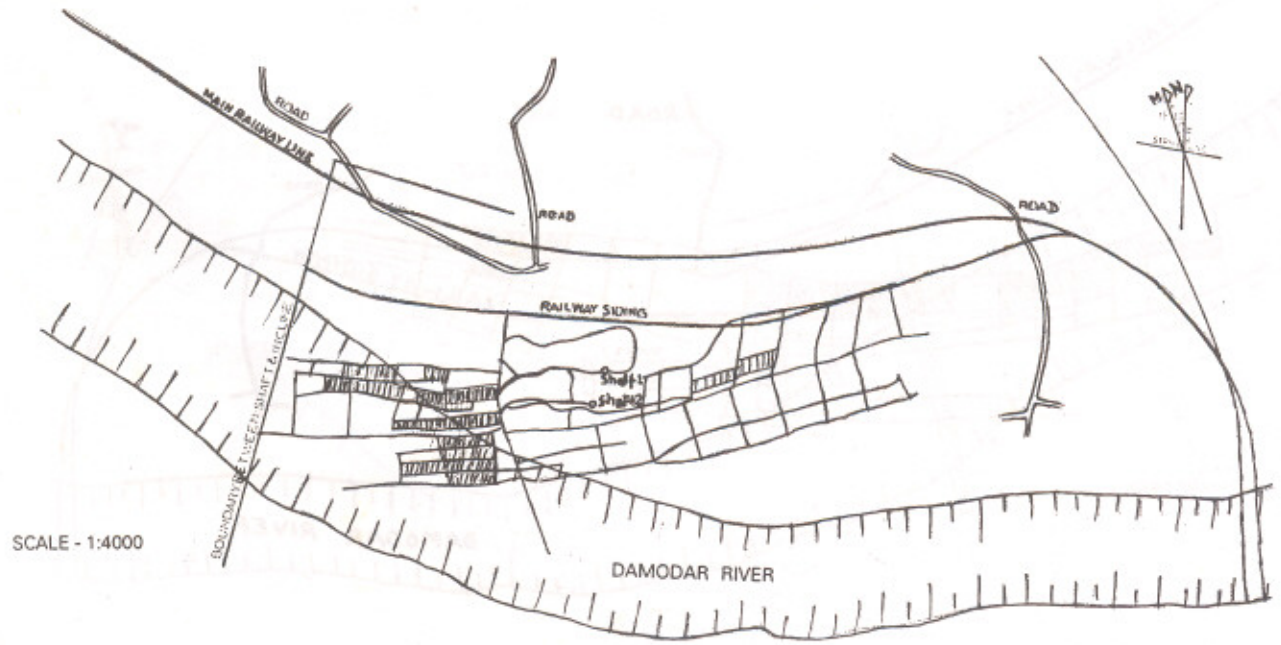

Fig. 11 : Sudamdih Shaft Mine XV Seam

OBSERVATIONS

The observations in the area under review are as follows :

1. **Visual :** Visually no distortion was observed in the Adra-Gomoh main railway line. It is difficult to make out, visually, that the main railway line has subsided by a maximum of 672mm since 1971.

2. **Subsidence and time :** The subsidence observed at monitoring station 36, 57 and 95 along Adra-Gomoh main railway line is shown in Fig. 4. It is evident from Fig. 4 that :

   — at times there was reduction in subsidence or lifting of ground, and

   — the rate of subsidence shows a slowing tendency at stations 36 and 57 and gradually increasing tendency at station 95.

3. **Profile of railway line :** Fig. 5 shows the profile of the railway line observed in January 1978 and August, 1995.

   In January 1973 the profile of the railway line was studied and it was found that in some length (about 300m) the gradient was 1 in 104, which was acceptable gradient (the limiting operating gradient of railway line is 1 in 100).

   Table 2 shows the gradient of the railway line observed in the different years and corresponding values of maximum subsidence along the railway line since 1973. It can be seen that the long gradient between CB and CJ was 1 in 138, and between CJ & CX it was 1 in 102 in January 1978, and between CB and CX, it was 1 in 112.5. It was 1 in 124 and 1 in 115 and 1 in 118, respectively in August, 1995. Hence, it is concluded that there has been no appreciable change in the railway gradient since January, 1978, as the long gradient of the railway line is flatter than 1 in 100.

4. **Maximum subsidence, slope and strain :** The maximum subsidence, slope and strain along the railway line in different years since 1971 are presented in Table 3. Fig. 6 and Table 3 also show that the railway line has been subjected to :

   Maximum subsidence : 672 mm
   Maximum slope : 83 mm/m
   Maximum compressive strain : 3.0 mm/m
   Maximum tensile strain : 3.1 mm/m upto Aug.'95

   Fig. 7 to 11 show the monitoring stations and workings of VIIIA, IX/X, XI/XII, XIV and XV seams respectively.

Table 2

Gradient of the railway line

Year	Gradient between (1 in) CB & CJ	CJ & CX	CB & CX	Max. Subsidence (mm)
1973	145	104	—	184.3
1974	138	103	—	256.0
1975	134.5	102.3	—	334.3
1977	144	101.8	—	364.7
1978	138	102	114	374.2
1979	139	104	115	384.6
1980	138	103	115	396.4
1981	139	103	115	404.5
1982	138	103	115	412.6
1983	138	102.8	114	431.7
1984	135	102.6	113.6	456.6
1985	133	103	113.5	505.9
1986	128	103.7	112.6	556.6
1987	126	104	112	621.8
1988	126	105	113	630.0
1989	136	104	115	655.2
1990	121	110	114	660.0
1991	120.7	111.6	114.7	663.0
1992	121	112.5	115	668.0
1993	122	114	117	672.0
1994	124	115	118	672.0
1995	124	115	118	672.0

Table 3

Maximum subsidence, slope and strain along railway line

Month & Year		Maximum subsidence (mm)	Maximum slope (mm/m)	Maximum strain Compressive (mm/m)	Tensile (mm/m)
March	1971	0.0	0.0	0.0	0.0
Feb.	1972	72.5	3.45	1.5	1.6
Feb.	1973	184.3	4.73	1.6	2.7
Feb.	1975	321.2	6.75	1.8	2.2
Feb.	1977	364.7	5.46	1.4	2.9
Feb.	1979	384.6	6.00	1.5	2.6
Feb.	1981	404.5	6.20	1.8	2.5
Feb.	1983	431.7	6.16	1.8	2.9
March	1984	456.6	6.45	1.5	2.6
July	1985	505.9	6.76	2.0	2.0
May	1986	556.6	7.28	2.6	2.6
Oct.	1987	621.8	7.30	2.5	2.6
Dec.	1990	660.0	8.20	3.1	3.0
June	1992	668.0	8.20	3.1	3.0
Feb.	1993	672.0	8.20	3.1	3.1
Dec.	1994	672.0	8.30	3.0	3.1
Aug.	1995	672.0	8.30	3.0	3.1

CONCLUDING REMARKS

The experience gained at Sudamdih mines formed a basis, with sufficient confidence to the practising mining engineers in coal mining industry, for coal extraction elsewhere under similar conditions.

About 8-million tonne of coal has been extracted from underneath and in the vicinity of the main railway line, while the railway line has been gradually made to subside by a maximum of 672 mm in a controlled manner without affecting its normal operation.

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